SCIENCE FOR GLASS PRODUCTION

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TESTING OF LAMINATED GLASS FOR BULLET-PROOF CAPACITY

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The results of comparative testing of laminated glass fired at using a Makarov pistol are given. It is demonstrated that the use of glass sheets after special thermal treatment in laminated glass articles makes it possible to reduce their weight and the energy consumption and to improve the light transmission.

The idea of using sheet glass subjected to special heat treatment (SHT-glass) in laminated articles has been voiced several times [1, 2]. Traditional laminated bullet-proof glass is a composite consisting of several annealed silicate-glass sheets cemented by polymers or other adhesives (GOST R 51136–98). Due to the relatively low strength of annealed glass, the thickness of such structures ranges from 20 to 75 mm depending on the protection category, which significantly increases the weight of articles and the amount of energy consumed in their production. Attempts at using hardened glass in such composite structures have not succeeded due to the self-sustaining type of destruction of such glass under a surface damage to a certain depth and each sheet breaking into small fragments.

It has been established earlier that the thickness of bullet-proof glass can be significantly increased provided it consists of SHT-glass sheets. As the first stage, we limited ourselves to preparation and testing of glasses classified as protection grade 1 according to GOST R 51136–98 standard that includes firing a Makarov pistol. The purpose of the experiment consisted in relative testing of traditional laminated glass (reference samples K) and experimental glass (E) of smaller thickness consisting of glass sheets after special heat treatment. The SHT-glass sheets were produced at a vertical glass-making plant of unique design at the Ural Glass Company in the conditions calculated earlier [2].

Glasses K and E were prepared simultaneously in identical conditions using the traditional scheme: glass preparation → preparation of adhesive film → packing → rolling → autoclave treatment. Comparative tests (shooting) were carried out under the maximum compliance with GOST R 51135–98 requirements, the testing including videotaping and photography.

Samples with a surface area of 500 × 500 mm were inserted in a specially made frame with rubber sealings, an attachable outer frame, and screw cramps for reliable fixing of the object fired at (Fig. 1). Testing was carried out on the Belgorod Regional Police shooting ground that met all requirements of the specified state standard.

The characteristics of samples prepared for testing at the first stage are represented in Table 1. The adhesive material was Trosifol polyvinyl butyral film (Finland) and the backside protection was provided by the Jlymar film (U.S.).

The testing method included consecutive firing at each sample from a distance of 25, 15, and 10 m aiming at the vertex of an equilateral triangle with side 125 mm long. After each shot, the sample was inspected and the type of destruction caused by the bullet was recorded (Fig. 2). The results of testing bullet-proof capacity are indicated in Table 2.

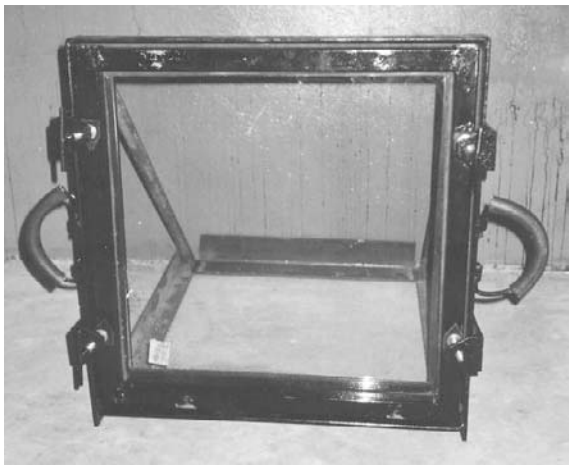

Fig. 1. Glass fixed in the frame.

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TABLE 1

Sample	Product formula*	Existence of backside protective film
K3	5(0.38)5(0.38)5(0.38)5	None
K4	6(0.76)6(0.76)6	The same
E2	5(0.76)5(0.76)5	″
E3	6(0.76)6[0.28]	Exists

* 5 and 6 is the nominal thickness of glass, mm; (0.76) and (0.38) is the nominal thickness of adhesive, mm; [0.28] is the thickness of the backside protective film, mm.

TABLE 2

Shooting distance, m	Depth of penetration of the bullet into the sample, mm*			
	K4	K3	E3	E2
25	2.6	1.82	4.7	6.1
15	3.2	2.2	6.7	–
10	5.4	1.8	7.0	–

* Only sample E2 was perforated from distances of 15 and 10 m.

Of the samples tested only sample E2 had unsatisfactory results. All other samples yielded positive result: there was no perforation. Measurements of the bullet trace in each sample that had passed the test revealed a substantial allowance with respect to the bullet penetration depth, i.e., 30 – 50% of the total thickness of the glass.

Changeover to the new type of product in industrial conditions will provide for a 1.5 times-decrease in thickness, weight, and material consumption and will decrease the consumption of energy in autoclave treatment, at the same time decreasing the consumer's expense on fixtures when installing this glass and improving the light-permeability parameters of multi-layer glass.

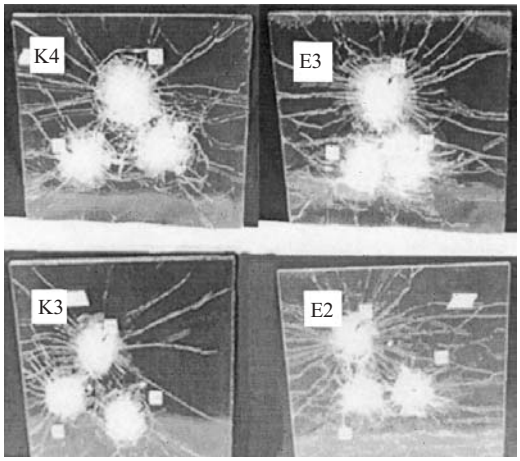

Fig. 2. Reference and experimental samples after shooting.

REFERENCES

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